National Transportation Safety Board
Aviation Accident Final Report

Location:	NEWARK, NJ	**Accident Number:**	NYC99FA032
Date & Time:	12/03/1998, 1742 EST	**Registration:**	N44NY
Aircraft:	Eurocopter EC-135-P1	**Aircraft Damage:**	Destroyed
Defining Event:		**Injuries:**	2 Minor
Flight Conducted Under:	Part 91: General Aviation - Aerial Observation		

Analysis

The pilot flew the helicopter below and behind the flight path of an airliner, and encountered wake turbulence. He inadvertently rolled the throttles to manual, and never restabilized the engines or main rotor rpm. In addition, he did not understand the reset procedures for the engine controls (FADEC), and never returned the engines to FADEC control. After about 2 minutes of flight with several power changes, and a climb of 700 feet, rotor RPM had decreased to 73%. The pilot declared an emergency, reported a double power loss, and ditched the helicopter in a river. A video of the last several seconds of the flight revealed periodic bursts of flames, and bright objects emitted from the rear of the helicopter before it contacted the water. Although the left engine had been overtempted, and experienced turbine failure, the right engine was capable of producing power at water impact. A failed hydraulic line was found in-line with a failed coupling on the tail rotor drive shaft, in an area where a fire had burned. The mfg reported the tail rotor drive shaft could become unstable above 168% Nr, or lower if the mounts were loose or rubber grommets deteriorated. A sound analysis recorded the main rotor momentarily at 125% Nr during the autorotation. A fault code from the right engine FADEC indicated the power turbine had reached 127% Nr. The hanger bearings for the long tail rotor drive shaft had not been retorqued as required after being replaced. Non-mechanic rated pilots had signed off 100-hour inspections, and required inspections from airworthiness directives.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be: the pilot's failure to maintain proper rotor rpm and his improper in flight decision to enter autorotation due to his lack of knowledge of the power plant controls. Factors in the accident were the night conditions and the pilot's improper decision to fly through wake turbulence.

Findings

Occurrence #1: LOSS OF CONTROL - IN FLIGHT
Phase of Operation: CRUISE

Findings
1. (F) LIGHT CONDITION - NIGHT
2. (F) IN-FLIGHT PLANNING/DECISION - IMPROPER - PILOT IN COMMAND
3. (F) WAKE TURBULENCE - ENCOUNTERED - PILOT IN COMMAND
4. (C) POWERPLANT CONTROLS - NOT UNDERSTOOD - PILOT IN COMMAND
5. (C) ROTOR RPM - NOT MAINTAINED - PILOT IN COMMAND
6. (C) IN-FLIGHT PLANNING/DECISION - IMPROPER - PILOT IN COMMAND
7. (C) AUTOROTATION - INITIATED - PILOT IN COMMAND
8. MAINTENANCE - IMPROPER - COMPANY/OPERATOR MANAGEMENT

Occurrence #2: FIRE
Phase of Operation: DESCENT - EMERGENCY

Findings
9. ROTOR RPM - EXCEEDED - PILOT IN COMMAND
10. ROTOR DRIVE SYSTEM,TAIL ROTOR DRIVE SHAFT - DYNAMIC IMBALANCE
11. HYDRAULIC SYSTEM,LINE - CUT/SEVERED
12. 1 ENGINE - OVERTEMPERATURE

Occurrence #3: IN FLIGHT COLLISION WITH TERRAIN/WATER
Phase of Operation: DESCENT - EMERGENCY

Findings
13. TERRAIN CONDITION - WATER

Factual Information

HISTORY OF FLIGHT

On December 3, 1998, about 1742 Eastern Standard Time, a Eurocopter EC-135-P1 helicopter, N44NY, operated by Aerial Films Inc, was destroyed during a precautionary landing in the Passaic River, Newark, New Jersey. The certificated airline transport pilot and camera operator received minor injuries. Night visual meteorological conditions prevailed for the aerial observation flight that originated from Palisades General Hospital Heliport (07NJ), North Bergen, New Jersey, about 1645, and was planned to terminate at Essex County Airport, Caldwell, New Jersey. No flight plan had been filed for the flight, which was conducted under 14 CFR Part 91.

The helicopter was engaged in electronic news gathering (ENG) for a local television station, and used a radio call sign of CHOPPER 4. According to the air/ground communications tape from the Federal Aviation Administration (FAA), at 1736:30, the pilot contacted the control tower at Newark International Airport (EWR), Newark, New Jersey, and was cleared into the Class B airspace to cover a story near downtown Newark.

The planned route of flight took the helicopter west, across the final approach course for Runways 22L/R. At 1738:02, prior to the helicopter crossing the final approach course, the Newark local controller advised the pilot of traffic, 4 miles away, an MD-80, descending out of 2,000 feet. The pilot was instructed to report when he had the traffic in sight.

At 1738:08, the pilot transmitted, "chopper four has the m d eighty, we'll maintain visual separation", which was acknowledged by the local controller.

At 1739:05, the pilot transmitted, "chopper four got the next arrival behind the m d eighty."

As the helicopter proceeded west toward its destination, the pilot was advised of other helicopters in the same area, and reported that he had visual contact with them.

The onboard gyro-stabilized camera was pointed toward Newark airport, and transmitting to the parent television station. An airplane similar in lighting configuration to an MD-80 was seen descending into Newark. At 1739:53, as the helicopter neared the extended centerline of Runway 22L, the camera recorded a momentary vertical oscillation.

Both occupants were wearing David Clark headsets. The pilot was talking to the Newark local controller, and the camera operator was talking to the news desk. The camera operator's microphone recorded some of the conversation from the pilot. In addition, the background noise, which consisted of wind, engines, transmission, and the main rotor blades, was also recorded.

Following the vertical oscillation, there was a discussion between the pilot and camera operator as to what had happened. The background noise, which had been constant prior to the vertical oscillation, became variable with noticeable increases and decreases in frequency and intensity.

According to a transcript of the onboard conversation prepared by the Safety Board cockpit voice recorder laboratory, at 1740:19, the pilot was believed to have stated,"...i'm turning the throttles...."

At 1741:16, the pilot said, "turn the light on and get it out so it turns down."

According to a Safety Board CVR analysis of the background noise from the onboard recording system, at 1741:48, the main rotor RPM had decreased to 73 percent.

At 1741:51, the pilot transmitted, "mayday mayday chopper four is...."

The sound analysis of the background noise also revealed a rapid increase in main rotor rpm, to about 125 percent, which occurred at 1741:53, after which the camera operator stopped the onboard recording.

At 1741:56, the pilot transmitted, "mayday mayday, our engines are out, we're going down." The Newark local controller acknowledged this. No further transmissions were received from the helicopter.

The pilot of another nearby helicopter reported that when he heard the mayday call, he scanned for, and visually acquired "Chopper 4." He then flew toward Chopper 4, and his camera operator aimed their onboard camera at it.

The video was about 25 seconds in duration; however, the helicopter was not visually acquired until 9 seconds had elapsed after the start of the tape. The video was initially taken from the right side of, and then from behind Chopper 4. When Chopper 4 was visually acquired, a momentary burst of flame was observed emitting from the helicopter. The source could not be determined.

As Chopper 4 continued to descend, the glow of both engines could be discerned. Occasional bursts of flame were seen from the rear of the helicopter; however, the exact location they originated from was not determined. About 5.5 seconds prior to water impact, as the helicopter slowed and descended, bright flashes were observed, and several bright glowing objects exited from the rear of the helicopter and fell toward the ground.

During the descent to the water, the helicopter maintained its heading. As the helicopter struck the water, a bright flash was observed near the rear of the fuselage. The flash was obscured by the water spray, after which, the helicopter disappeared from view, and the tape stopped.

At 1742:23; the pilot of the following helicopter transmitted to Newark control tower, "he's [Chopper 4] in the water now...."

The occupants reported they exited the helicopter and swam to shore. Emergency vehicles were on scene within 2 minutes.

When interviewed, the pilot reported that before the crash, the helicopter had encountered a "violent" vertical oscillation which he described as "hard and abnormal", with minimal left-right yawing. He did not recall any noise accompanying the oscillation. He had scanned the gages and everything looked normal. The pilot had seen an airliner about to land at Newark, and thought he may have encountered wake turbulence. His next memory was of being in the hospital.

The camera operator reported the helicopter was headed west over the Stickel Bridge toward downtown Newark, when he felt something like a bird strike on the tail rotor blades. He said the vertical oscillation was the largest event he had experienced in-flight. The helicopter momentarily "dropped" and then continued. The camera operator said the pilot thought it was turbulence, but the camera operator reported that he was skeptical. Everything seemed "OK", and the flight continued toward the news story location.

The camera operator further reported that when the pilot asked for the light to be turned on, he initially thought the pilot wanted the external searchlight on. However, the pilot reported that he had wanted the overhead internal spotlight shown on the collective mounted throttles, located between the seats. The camera operator also reported that he noticed the main rotor rpm had decreased, and the rotor light had illuminated and stayed on until the helicopter struck the water.

The camera operator also reported that during the descent, the helicopter started to become unstable like it was in turbulence. He thought the pilot was visibly shaken, but was still flying, and he tried to get the pilot to relax. The pilot said he was going to put the helicopter down in the river. Further, the camera operator reported in his statement, "...I began to smell what seemed to be burning metal as we continued to descend...."

The camera operator reported that he had removed his seatbelt and shoulder harness before touchdown, and upon water impact was not thrown out of his seat. He also opened the left side cockpit door before water impact. The skids hit first, and he exited the helicopter. He felt a main rotor blade strike him in the head after he exited the helicopter. He was uncertain if the helicopter rolled after touchdown.

In a follow-up interview, the camera operator reaffirmed there was no noise or yawing of the helicopter, when they encountered the vertical oscillation. It was about the vertical axis only. After the mayday call, the helicopter continued in coordinated flight, while it oscillated. The accident occurred during the hours of darkness, at 40 degrees, 46.10 minutes north latitude, and 74 degrees, 09.42 minutes west longitude.

PERSONNEL INFORMATION

The pilot held an airline transport pilot certificate. His total flight experience was 3,926 hours, with 123.8 hours in make and model. He had flown 64 hours in the preceding 90 days, with 60 hours in make and model. His last flight review was conducted on November 18, 1997, in a Bell 206. He held a type rating in a Bell 204.

He was last issued a FAA first class airman medical certificate, with no limitations, on July 10, 1998.

According to documents from American Eurocopter, the pilot was trained on the EC-135, in July 1998, at Morristown, New Jersey. The training included ground school, and 3.2 hours of flight training. The training included operation of the helicopter with engines in manual control, and returning the engines to full authority digital engine control (FADEC) once they were in manual.

ORGANIZATIONAL AND MANAGEMENT INFORMATION

The helicopter was operated by Aerial Films, Inc, and was under contract to the local NBC affiliate in New York City. The responsibility for pilot training, operations, and maintenance of the helicopter, remained with Aerial Films. Both the pilot and camera operator were employees of Aerial Films.

AIRCRAFT INFORMATION

The helicopter was manufactured, assembled, and tested in Germany. It was then disassembled and shipped to the American Eurocopter (AEC) facility in Grand Prairie, Texas. The engine and main transmission were serviced with Mobil Jet II, a synthetic lubricant. In Germany, the hydraulic system was serviced with Shell brand Mil-H-5606 fluid hydraulic fluid.

At the AEC facility, and in Morristown, New Jersey, the helicopter had been serviced with Texaco brand Mil-H-5606 hydraulic fluid.

The helicopter was equipped with a single main rotor and fenestron tail rotor. At 100 percent rpm, the main rotor was turning at 395 rpm, the tail rotor drive shaft was turning at 4,986 rpm, and the fenestron tail rotor was turning at 3,584 rpm.

The original standard airworthiness certificate was issued on September 26, 1997. An experimental airworthiness certificate was issued on December 9, 1997, to flight test electronic news gathering equipment that was installed. On December 23, 1997, he helicopter was weighed. On December 24, 1997, the Chief Pilot of Aerial Films conducted a flight test on the installed equipment. On January 19, 1998, the helicopter was issued another standard airworthiness certificate.

The helicopter was maintained under an inspection program recommended by the manufacturer, which included pre-flight inspections, 50 hour and 100-hour complementary inspections, a 400-hour intermediate inspection, an 800-hour periodical inspection, and a 12-month inspection.

The engines were equipped with electronic controls, manufactured by the Hamilton Sundstrand Corporation, a subsidiary of United Technologies, and referred to by them as electronic engine controls (EECs). All references in the Eurocopter flight manual referred to them as FADECs.

The throttles were mounted on the collective with the forward throttle for the left engine, and the rear throttle for the right engine. A white line and the letter N on the throttles, which aligned with a white arrow on the collective, identified the neutral position of the throttles. There was a noticeable detent when the throttle was rolled across the neutral position, which matched the painted positions that were mid-way between the full open and minimum idle positions. Normal flight was conducted with the throttles in the neutral position, and with control of the engines conducted by the FADECs. The FADECs provided several functions, which included the scheduling of fuel and maintaining engine operation within pre-determined limits.

The helicopter was equipped with a red warning light for main rotor rpm speed. When the main rotor rpm was above 106 percent, the light would flash, and when below 95 percent, the light would be illuminated in a steady state. The green arc on the main rotor tachometer was from 80 percent to 106 percent.

The helicopter had two fuel tanks, the supply tank, and the main tank. The supply tank was fed from the main tank and was used as constant source of fuel for the engines. In normal operations, the supply tank would remain full until the main tank was empty, after which the fuel would decrease in the supply tank. Fuel added to the main tank moved the center of gravity forward. Fuel added to the supply tank moved the center of gravity rearward

Examination of weight and balance data for the helicopter revealed the empty weight of the helicopter was 1,882.49 kilograms (kg). The maximum allowable gross weight was 2,720 kg. The weight of the helicopter at the time of accident was estimated to be 2,507 kg. The center of gravity was estimated to be 49 millimeters (1.93 inches) forward of the forward limit. According to Advisory Circular 61-13B, Basic Helicopter Handbook, Chapter 7, Weight and Balance, "Out of balance loading of the helicopter makes control more difficult and decreases maneuverability since cyclic stick effectiveness is restricted in the direction opposite to CG location."

RADAR AND OTHER REMOTELY RECORDED DATA

Recorded radar data was obtained from the New York Terminal Area Radar Control (TRACON). The track and altitude of the helicopter, along with several arriving airplanes were plotted. The last airplane to arrive prior to the passage of the helicopter was identified as a MD-82. The data revealed that the helicopter passed behind the MD-82, 200 feet below, at an altitude of 700 feet MSL, and 36 seconds after its passage. Over the next 2 minutes, the helicopter continued to the west and then north. It also climbed from 700 feet to an altitude of 1,400 feet.

WRECKAGE AND IMPACT INFORMATION

The helicopter came to rest on its left side in about 6 feet of water. Divers reported that the tail boom was physically separated from the fuselage, and restrained by a steel cable, which was later identified as the control cable to the fenestron tail rotor. The control cable was cut, and the fuselage and tail boom removed from the river. The helicopter was then transported to Teterboro Airport (TEB), Teterboro, New Jersey, for further examination.

The fuselage floor was fractured between the middle and rear rows of seats. The paneling on the bottom of the fuel tank was not recovered. However, the fuselage fuel tank bladder mounted in the lower aft fuselage was not ruptured or leaking.

The helicopter was equipped with attenuating seats that were designed to collapse downward under increased "g" loads. Post-accident examination revealed that both occupied crew seats had collapsed downward, and neither occupant received serious injuries.

The main rotor blades were found with splits on the skin at the trailing edge of the blades. In addition, two blades were fractured, perpendicular to the plain of rotation. Small indentations and breaks were found on the leading edges of the blades. In addition, there was an indentation on the left side of the tail boom, which was consistent with a main rotor blade strike. None of the main rotor pitch link control rods were broken.

Breaks were observed in the flight control system in the following locations: rudder bell crank, right lateral cyclic, and aft cyclic. All fractures had bright granular surfaces. In addition, a collective push rod tube was crushed, and the control cable for the fenestron tail rotor had been cut before the tail boom and helicopter were removed from the water separately. All other connections in the flight control and tail rotor control system were intact. Flight control continuity was confirmed for other than the previously mentioned conditions.

Aft Fuselage

The aft fuselage behind the passenger cabin was divided into upper and lower sections. The lower section housed electronic components, and had space for a baggage compartment. The upper section housed several components including the main transmission, both engines, two firewalls, and the forward portion of the tail rotor drive. Air intakes on the upper fuselage, forward of the main rotor mast, led to a tunnel behind the main transmission. The tunnel was about 12 inches wide, with a crowned, titanium deck, and also served as a source of air for the engines, which were mounted on each side. The left engine was referred to as the number 1 engine and the right engine referred to as the number 2 engine. The tunnel continued aft, to the aft end of the fuselage, where the tail boom was connected.

There were two titanium firewalls installed in the air intake tunnel. Both firewalls were orientated laterally, and spanned the width of the tunnel. The forward firewall was held in place by metal clips on the sides, and was at the aft side of the air intakes for the engines. The aft firewall was held in place with cam lock fasteners, and was about 6 inches further aft. It also had two side panels, which separated the aft engine compartments from the aft end of the tunnel between the engines.

The helicopter was equipped with two hydraulic systems that used Mil-H-5606. The hydraulic pumps were mounted on the main rotor transmission. The number 1 hydraulic system, which supplied boost for the main rotor control, was intact and full of fluid. The number 2 hydraulic system, which supplied boost for the main rotor control and fenestron tail rotor control, was empty. The capacity of the number 2 hydraulic system was 1.3 liters. The normal system pressure was 1,500 PSI. With the main rotor at 100 percent, the maximum flow rate of the number 2 hydraulic pump was 8.1 liters per minute.

Two hydraulic lines ran aft from the number 2 hydraulic pump to the fenestron tail rotor. The lines were in the center of the tunnel until after they passed the engine air intakes, and then they were aligned with the right side of the tunnel. Examination of the left engine revealed the last row of turbine blades were fractured about mid-span. Additional damage was observed on the trailing edge of the preceding row of guide vanes. Although the left engine exhaust pipe was pitted, there was no penetration of either the exhaust pipe or engine case from the turbine blades. The right engine turbine blades did not appear to be damaged.

Plastic bottles had been installed in the engine compartment to collect engine oil overflow or runoff. The bottle on the left engine was destroyed by heat. The bottle on the right engine was intact, and hung below the engine. There was no open path for the oil from the bottles to the air intake tunnel. Examination of the maintenance logbook revealed no entry for the installation of the bottles. An engineer from the FAA rotor certification office reported that he visited the AEC facility in Texas, and they were not installing the bottles.

Output shafts connected the engines with the main transmission. During the examination, when the engine output drive shafts were rotated by hand, the main rotor turned in the direction of rotation. The freewheeling clutch on the transmission was tested and was operational

The tail rotor drive consisted of three sections; the forward short drive shaft (forward shaft), the long drive shaft (long shaft), and the aft short drive shaft (aft shaft). The forward shaft extended from the aft side of the transmission to the aft end of the fuselage in the tunnel, and was connected to the forward end of the long shaft. The long shaft was mounted along the top of the tail boom, and connected the forward shaft to the aft shaft. The aft shaft connected to the gearbox for the fenestron tail rotor. Thomas couplings were used for all tail rotor drive shaft couplings. All Thomas couplings were intact except for the connection between the aft end of the forward shaft, and the forward end of the long shaft, at the aft end of the tunnel on the fuselage.

The long shaft was held in place by six brackets. Each bracket had a rubber grommet that the drive shaft passed through.

The aft end of the long shaft fit into a Thomas coupling sleeve, and was fractured. Rotational scoring marks were visible on both the shaft that fit into the sleeve, and on the inside of the sleeve.

The forward 6 inches of the long shaft was bent about 30 degrees from its alignment, and the shaft was rotationally twisted about 30 degrees. In addition, the forward hanger-bearing mount for the long shaft was fractured, and displayed a bright granular surface. The edges of the fracture surface on the mount were bright and smooth.

Forward Shaft

Rotational scoring marks were visible on the aft 12 inches of the forward shaft. Most of the rotational scoring marks were between 1.75 and 9 inches forward of the aft end of the shaft. Several deep gouges were in this area, with soot visible in some of the gouges. The rivets used to attach the sleeve of the aft Thomas coupling to the forward shaft, exhibited rotational scoring across the heads in the plain of rotation, with soot in the grooves. The outer circumference of the flanges on the Thomas coupling had rotational scoring marks.

The last 1 inch of the forward shaft, which extended aft through the rear firewall, was sooted with some small areas where bare metal was exposed. Forward of the soot, to 11 inches forward from the aft end of the forward shaft, the paint was burned away. From 11 to 17 inches forward of the aft end, the paint was partially burned away, and the forward shaft was sooted.

A lateral cut was found in the titanium floor of the tunnel, at the aft end. The cut contained rotational scoring marks, and was aligned with the flange of the Thomas coupling between the forward and long shafts. The cut measured about 5-inches wide and about 1/2-inch long. Lateral scratches were found from the cut to about one inch forward of the cut.

A hydraulic line with a braded steel covering on the right side of the fuselage, aligned with the cut in the fuselage and the Thomas coupling, was broken open and deformed in its fitting. A rubber covering, with a nylon chord built into it, was also broken open in the same area.

The Thomas coupling between the aft end of the forward shaft, and the forward end of the long shaft was fractured.

Firewalls

Both firewalls had openings that allowed the forward shaft to pass through from the transmission to the long shaft. The metal around the hole on each firewall was deformed upward and laterally. Teflon rub protector liners had been attached to each hole. Each segment covered 180 degrees of the hole. One was located on the upper half of the forward firewall, and two were located on the upper and lower half of the aft firewall.

On the forward firewall, half of the segment was recovered, still attached to the firewall, and exposed to heat. The other half of the liner was found, separated from the firewall and not exposed to heat.

On the aft firewall, both half circles were recovered. One had been exposed to heat, and the other one had not been exposed to heat.

Rotational scoring was visible on the inside radius of the unburned Teflon liners.

The left sidewall of the aft firewall was discolored blue. The size of the discoloration was about 12 inches by 12 inches. The bluing was opposite of the cut hydraulic line. Additional bluing was visible on the forward or lateral side of the aft firewall. This was in the same area as the cut in the floor of the aft tunnel, and the burned inside surface of the cowling.

Cowlings

Fiberglass cowlings were used to cover the engines, and air intake tunnel. A center cowling passed over the air intake tunnel and extended forward and aft of the aft firewall. The inside surface, aft of the aft firewall was sooted with the resin burned out of the fiberglass fibers. The inside surface of the cowling, forward of the aft firewall showed no signs of exposure to heat or sooting. The outside surface of the cowling over the burned area showed no evidence of exposure to heat, and was indistinguishable from the outside surface of cowling over an area where its underside had not been exposed to heat. The cowling over the engines was not discolored. There were two air vents in the cowling, located inboard of the two engine exhausts. Each vent was sooted in the immediate vicinity of the vent.

Tail Boom

The tail boom was separated from the fuselage at the attach point. The fracture surface was examined with a 10-power hand lens, and found to have a bright granular appearance. Next to the attach point, the topside of the painted fiberglass surface was sticky to touch. About 12 inches aft of the separation point on the tail boom, the fiberglass was soft and the paint had been cracked off. This area was about 1-inch wide and extended for 180 degrees on the upper half of the tail boom.

The fiberglass covering over the bottom of the fenestron tail rotor was cracked, and crushed upward. Rotational scoring marks were visible on the inside bottom of the protective ring that surrounded the fenestron rotor.

TESTS AND RESEARCH

Metallurgical Examination

According to the Safety Board Metallurgist who examined the failed Thomas Coupling, and number 1 hanger bearing, no evidence of fatigue was found. Both fracture surfaces revealed evidence consistent with overload.

Engines

The engines were disassembled at the Pratt & Whitney of Canada (PWC) factory in Longueuil, Quebec, Canada, under the supervision of the Safety Board.

The air intake (T1) temperature probes on both engines had been exposed to heat sufficient to cause the inner contents of the probe to be expelled. Each probe was mounted on the lower left side of the engine case. Material from the right engine probe was found splattered on the bulkhead, near the top of the probe.

The air intakes of both engines were sooted. Leading edge damage was observed on the centrifugal compressors of both engines, with more damage on the right engine. Small pieces of metal were found at the entry to the diffuser of the right engine, past the tip of the impellers.

On the left engine, the power turbine and compressor turbine blades were fractured mid-span. On the right engine, the protective coating on the compressor turbine blades was partially missing from the leading edge, and concave surface near the trailing edge of the blades. There were no blade fractures.

Other than the blade damage observed, there was no physical evidence of a mechanical failure or malfunction with either engine.

According to a report from PWC, the soot residue found on the intakes of both engines was determined to be from Mobil Jet II, which was used in the engines and main transmission. The determination was made on the basis that phosphates were found in the residue. According to information from the manufacturers of the fluids, Mobil Jet II and Texaco brand Mil-H-5606 contained phosphates. The helicopter's engines and main transmission had been serviced with Mobil Jet II, and the hydraulic system had been serviced with both the Shell and Texaco brands of Mil-H-5606.

FADECs/EECs

The FADECs were examined at the Hamilton Sundstrand facility, under the supervision of the Safety Board. Data was retrieved from the non-volatile memory of both units. The FADECs could record 64 faults related to engine operation. Faults were written to non-volatile memory by a write cycle, which took 5.32 seconds to check all temporary fault memory locations for detected faults.

When detected faults were written to the non-volatile memory, the engine rpm at the time the fault was written to memory was also recorded. The engine rpm when the fault was detected, was not recorded.

The timing error between a fault being detected, and written to memory could range from 0 to 5.32 seconds. In the event of a loss of electrical power, faults that had been identified, but not written to memory, were not retained.

According to personnel from Hamilton-Sundstrand, when one inlet temperature probe was not available, the engine control would use the temperature probe data from the other engine. FADEC data revealed that both engines had experienced fault code 57, multiple non-critical T1. This fault indicated a loss of both the local T1 (temperature probe on engine) and loss of the remote T1, (temperature probe on other engine). The engine RPM recorded when this fault code was written, was 58.73 percent gas generator (Ng) for the left engine, and 86.63 percent Ng for the right engine. Personnel from Hamilton Sundstrand reported that this fault code would place both engines in manual, if they were operating under FADEC control. According to PWC, the minimum idle speed would be between 50 and 60 percent Ng, depending upon several variable factors.

The recorded faults revealed that both engines had experienced fault code 23, inlet temperature. On the left engine, the recorded engine rpm was 41.7 percent Ng, and on the right engine, the recorded engine rpm was 88.99 percent Ng.

Hamilton Sundstrand reported that to achieve the stored information associated with fault code 23, the engine temperature sensors had to be exposed to a temperature of less than -88 degrees Celsius, or greater than 141 degrees Celsius, by passing three temperature thresholds of increasing or decreasing values in sequence.

In addition, on the right engine, fault code 49, primary and secondary free turbine speed/torque, was written to memory at 90.16 percent Ng. According to a letter from Hamilton Sundstrand, one possibility was that Ng was above 70 percent, and power turbine was either below 20 percent, or above 127 percent.

MANUAL ENGINE CONTROL

If either throttle were rolled out of the neutral position, two lights would illuminate on the cockpit display system. They were the ENG MANUAL (engine manual), and the TWIST GRIP light. The ENG MANUAL indicated that the FADEC was no longer controlling that engine, and movements of the collective up or down would not automatically result in engine power changes. The TWIST GRIP light indicated that the throttle was not in the neutral position, but was unaffected by whether the engine was in manual or under FADEC control. The flight manual carried the following warning about operating the engines in manual:

"OPERATE THE TWIST GRIP WITH GREAT CARE AND AVOID QUICK TWIST GRIP ROTATIONS."

The flight manual also noted that if a throttle was rolled from the neutral position, the actuation of the engine mode selector switch to MANUAL, then NORM, would reactivate the FADEC, even with the throttle still out of the neutral position. In that case, the ENG MANUAL light would extinguish. However, the TWIST GRIP light would remain illuminated.

Further, during such a condition, the throttle could be rotated with no change in FADEC status as long as the throttle was not rolled across the neutral position. Once the throttle was placed in the neutral position, the TWIST GRIP light would extinguish. However, if the throttle were rotated from the neutral position again, in either direction, the ENG MANUAL and TWIST GRIP lights would once again illuminate. In addition, the engine would revert to manual control, and the FADEC would need to be reset to place the engine under its control.

The investigation revealed that with one engine in manual, and the other under FADEC control, that a reduction in power on the manual engine would bring about an increase in power on the engine under FADEC control, up to the predetermined limits as controlled by the FADEC. If power was increased on the engine in manual, the power could increase to the limits controlled by the engine fuel control, and there would be a corresponding decrease in power on the engine under FADEC control.

In a follow-up interview, the pilot still had no memory of the accident. He was questioned about the procedures to return the engines to the control of the FADEC, and reported the throttles had to be in the neutral position, and the mode selector switch reset for the FADEC to regain control of the engine. He reported that if a throttle were out of the neutral position, and the mode switch reset, the return to FADEC control would not take place until the throttle had also been returned to the neutral position.

Cockpit Display System (CDS)

The cockpit display system was examined at the Grimes Division of Allied Signal under the supervision of the Safety Board. The non-volatile memory recorded the data displayed during the last minute of flight. According to the EC-135 flight manual, warning lights were displayed in order of illumination until they were acknowledged, at which point they fell into a predetermined priority order.

For the left engine, the top light illuminated was ENG MANUAL, followed by ENG FAIL, FADEC FAIL, FADEC MINR, ENG OIL P, GEN DISCON, FUEL PRESS, and HYD PRESS.

For the right engine, the top light illuminated was TWIST GRIP, followed by ENG MANUAL, FADEC FAIL, FADEC MINR, and HYD PRESS.

The TWIST GRIP and ENG MANUAL lights were previously described. FADEC FAIL indicated a loss of automatic acceleration and deceleration control on the engine. FADEC MINR indicated a change or loss of governing functions on the engine. ENG OIL P indicated a loss of engine oil pressure. GEN DISCON indicated the generator had disconnected. FUEL PRESS indicated a loss of engine fuel pressure, and HYD PRESS indicated a loss of hydraulic pressure.

Examination of the helicopter found the left engine throttle (forward) in the neutral position. The right engine throttle (rear) was found displaced from the neutral position towards the idle cut-off position.

Personnel from Eurocopter and the FAA rotorcraft certification office in Fort Worth, Texas, conducted a test on another EC-135. The engines were started, and the FADECs deactivated. The engines were then shut down one at a time, with no attempt to cancel the warning lights as they appeared. The following lights on the test EC-135 matched the order of the warning lights from top to bottom, found on the left engine of N44NY: ENG MANUAL; ENG FAIL; ENG OIL PRESS, GEN DISCON; and FUEL PRESS.

Warning Lights

The bulbs in the engine fire lights, and warning panel were examined for filament stretch. No stretch was observed.

Main Transmission

The main transmission was examined at the AEC facility, under the supervision of the FAA. There was no evidence of a pre-existing mechanical failure or malfunction with the transmission.

Fuel Control Units

The fuel control units were examined at Woodward Governor Company, Rockford Illinois, under the supervision of the FAA. Both units passed a functional test. Examination of the units and testing confirmed that it was not possible to determine whether either engine was operating with the fuel control in the FADEC controlled, or manual position at the time of water impact.

A fire specialist from the FAA Technical Center, Atlantic City, New Jersey, examined the helicopter on December 11, 1998. According to his written report:

"...Fire damage was observed above and below a section of titanium fire wall between the engines in the area of the tail rotor drive shaft. A mechanically damaged steel braided hydraulic line was present in the same area. The fluid was reported to be MIL Spec 5606 at an operating pressure of 1200 to 1500 pounds per square inch (psi). A section of the composite skin that attaches above the firewall was burned on the inner surface and undamaged on the outer surface. The resin was burned away on the entire lower surface and fibers were visible. The titanium firewall was discolored to a bluish color on the inner and outer surface of the left side and to a lesser degree on the forward side. The soot and residue pattern on the inner surfaces of the firewall was consistent with a burning spray pattern from the ruptured hydraulic line in a right to left direction. A composite bleed air duct within the same area was partially consumed by fire. A hole was present in the lower horizontal surface of the firewall, above the tail boom. The hole was not due to melting. A different section of the composite bleed air duct below the hole was partially consumed by fire and there was some sooting on other components below the hole. This area below the fire wall would be isolated from the burned area above it until the hole occurred."

"The burning of the resin in the composite materials and the discoloration of the titanium fire wall is consistent with a fire burning for more than a few seconds. The flow rate of hydraulic fluid through the damaged line was not determined. However, a small quantity of fluid under pressure and in a misted form could easily produce the degree of fire damage that was observed in that area. The quantity could be much less than the 1.2 liter system capacity. The time it would take the burning fluid to produce the fire damage that was observed depends on the intensity of the fire. A well atomized sustained spray of burning fluid might produce the fire damage in as little as 15 seconds. If there was only a very brief ignited spray followed by a burning of pooled fluid the time duration could be 30 seconds to one minute...An ignition source was not determined. Two possibilities are hot surface ignition caused by a steel bleed air duct in the area with bleed air reported to be approximately 1100 degrees F. or frictional sparks caused by rotational damage from the drive shaft against the lower surface of the titanium fire wall. Titanium has a greater propensity for frictional sparking than steel...."

PWC reported that the maximum temperature for the bleed air was about 650 degrees Fahrenheit.

In a follow-up telephone interview, the FAA fire specialist reported that heat was transferred three ways; conduction, convection, and radiation. He further amplified that while the airflow into an engine could reduce the heat transfer through convection, it would have no affect on heat transfer through radiation.

ADDITIONAL INFORMATION

Interviews

Interviews were conducted with four other pilots who worked for Aerial Films, including the Chief Pilot. Two knew the correct procedure for resetting the engines from manual to automatic, and two did not. In addition, four of the five pilots reported that it was easy to overspeed the main rotor system during an autorotation. They reported it was necessary to keep some pitch on the main rotor to prevent the overspeed. Two of the pilots reported the throttle could be rolled out of the neutral position easily. One other pilot thought the throttle friction was light, but also said it was similar to other helicopters.

The accident investigator from American Eurocopter, who participated in the on-site investigation, reported that normal procedure was to set the pitch of the main rotor blades to achieve normal rpm during an autorotation with minimum weight. He further stated, that increases in weight would have a tendency to drive the blades to a higher rotational speed during an autorotation.

Maintenance Records

The last recorded entry for the left and right, in the engine maintenance logbooks, was on June 20, 1998, when both electronic engine controls were changed. There was no record of any inspections including the required 12 month inspection.

Following are dates of the last several inspections found in the airframe logbooks, and Aerial Films flight records:

June 30, 1998 - 400-hour intermediate inspection - by certificated mechanic August 8, 1998 - 100-hour complementary inspection - by certificated mechanic September 23, 1998 - 50-hour complementary inspection - by pilot October 25, 1998 - 100-hour complementary inspection - by accident pilot November 24, 1998 -100-hour complementary inspection - by accident pilot 12-month inspection - None recorded

A FAA approved repair station originally maintained the helicopter. The last work done by the repair station was conducted on September 3, 1998. The operator then elected to use an on-call independent mechanic to maintain the helicopter.

The repair station mechanic was questioned about the maintenance manuals and he reported that he did not use the manuals supplied by Aerial Films, because he had an up to date microfilm system of manuals. When the maintenance manuals were examined, it was discovered no revisions had been posted since the helicopter was delivered.

American Eurocopter mechanics performed warranty work on the helicopter, and returned it to flight status on October 10, 1998, after a stator blade in the fenestron tail rotor was changed, and on October 26, 1998, after completion of a tail rotor drive shaft service bulletin, and replacement of the main rotor transmission.

The mechanic who performed the tail rotor drive shaft service bulletin reported:

"After installation of the drive shaft mod. EC135-53A-004, I explained the requirement of re-torque on the newly installed bearing brackets after 14 days of cure time to the liquid shim located on page 4 of 4, of the service bulletin."

Examination of the maintenance records found no entry to indicate the retorquing had been accomplished.

On November 26, 1998, the independent mechanic, employed by Aerial Films, replaced both engine fuel filters.

AIRWORTHINESS DIRECTIVES

In addition to the Eurocopter required inspections, the FAA had issued two airworthiness directives (AD) that affected the tail rotor drive system and fenestron trail rotor on the helicopter.

Airworthiness Directive 97-20-13 was issued to, "...prevent failure of the tail rotor and subsequent loss of control of the helicopter." It called for a repetitive visual inspection before the first flight of the day for cracks in the stator blades of the tail rotor.

Airworthiness Directive 98-15-25, was issued to, "...detect loose tail rotor drive shaft bearing...attachment bolts, or cracked bearing supports, which could result in loss of drive to the tail rotor and subsequent loss of control of the helicopter." It called for a repetitive visual inspection to the bearing supports for the long drive shaft, with the use of a 6-power hand lens at 3-hour time in service intervals.

Aerial Films used an internally generated form to record their daily flights, maintenance, and compliance with required AD inspections. Initially, these inspections were signed off by a certificated mechanic, and later by pilots that did not posses mechanic certificates.

The ADs specified a procedure for compliance. Each AD did make provisions for a person to apply to the FAA for an alternate means of compliance. There was no record that Aerial Films had applied to the FAA for an alternate means of compliance for the conduct of the inspections.

WAKE TURBULENCE - AERONAUTICAL INFORMATION MANUAL

According to the Aeronautical Information Manual (AIM), Chapter 7, Safety of Flight, Section 3, Wake Turbulence:

"...AVOID THE AREA BELOW AND BEHIND THE GENERATING AIRCRAFT, ESPECIALLY AT LOW ALTITUDE WHERE EVEN A MOMENTARY WAKE ENCOUNTER COULD BE

HAZARDOUS."

The following was also found.

"Flight tests have shown that the vortices from larger (transport category) aircraft sink at a rate of several hundred feet per minute, slowing their descent and diminishing in strength with time and distance behind the generating aircraft. Atmospheric turbulence hastens breakup. Pilots should fly at or above the preceding aircraft's flight path, altering course as necessary to avoid the area behind and below the generating aircraft....

Antitorque System Failure

According to AC-61-13B, Basic Helicopter Handbook, Chapter 9, Some Hazards of Helicopter Flight:

"If the antitorque system fails in forward cruising flight, the nose of the helicopter will usually pitch slightly and yaw to the right...The pitching and yawing can be overcome by holding the cyclic stick near neutral and entering autorotation...If sufficient forward speed is maintained, the fuselage remains fairly well streamlined; however, if descent is attempted at slow speeds, a continuous turning movement to the left can be expected...The helicopter will turn to the left during the flare and during the subsequent vertical descent...."

A review of the external video revealed that no yawing rotation of the helicopter was observed, nor was any reported by the flight crew.

Additional Engine Information

According to a letter from PWC:

"For any given engine gas generator rotational speed, coupled with any given value of T1, power will diminish and the engine operating temperatures will rise, with the rate of oxygen depletion in the airflow provided."

The letter further amplified that the fuel control unit measured the weight of the air going into the engine. Fuel was scheduled with the assumption that the air was free of contamination. Further, any contamination such as smoke would reduce the oxygen content of the air going into the engine, and could result in an over fuelling condition which would extend the flame pattern aft into the turbine area.

DRIVE TRAIN INFORMATION

According to a letter from the Manager of Flight Safety for Eurocopter Germany, "The theoretical resonance frequency of the drive shaft system for bending is 168 % rotor RPM ('shaft speed'). Drive shaft deflection can be initiated by deterioration of the rubber sleeves that hold the drive shaft, and/or a reduction in stiffness in the hanger bearing mounts. Flight tests have been conducted with excessively worn rubber sleeves at 117 percent main rotor rpm, and the forward short drive shaft developed pronounced deflections so that the forward short drive shaft was touching the Teflon rub protection liners." The letter further stated:

"...The re-tightening of the bolts of the bearing supports as mandated by Alert Service Bulletin EC135-53A-004 (within 14 days) is necessary in order to compensate any shrinking or settling of the liquid shim and to prevent consequential looseness of the brackets. We expect that non-compliance with this procedures might lead to adverse effects...."

All wreckage was released to the insurance adjustor on January 19, 2001.

Pilot Information

Certificate:	Airline Transport; Flight Instructor; Commercial	**Age:**	38, Male
Airplane Rating(s):	Multi-engine Land; Single-engine Land	**Seat Occupied:**	Right
Other Aircraft Rating(s):	Helicopter	**Restraint Used:**	Seatbelt, Shoulder harness
Instrument Rating(s):	Airplane; Helicopter	**Second Pilot Present:**	No
Instructor Rating(s):	Airplane Single-engine; Helicopter; Instrument Airplane; Instrument Helicopter	**Toxicology Performed:**	No
Medical Certification:	Class 1 Valid Medical--no waivers/lim.	**Last FAA Medical Exam:**	01/07/1999
Occupational Pilot:		**Last Flight Review or Equivalent:**	
Flight Time:	3926 hours (Total, all aircraft), 124 hours (Total, this make and model), 2652 hours (Pilot In Command, all aircraft), 64 hours (Last 90 days, all aircraft), 34 hours (Last 30 days, all aircraft), 2 hours (Last 24 hours, all aircraft)		

Aircraft and Owner/Operator Information

Aircraft Make:	Eurocopter	**Registration:**	N44NY
Model/Series:	EC-135-P1 EC-135-P1	**Aircraft Category:**	Helicopter
Year of Manufacture:		**Amateur Built:**	No
Airworthiness Certificate:	Normal	**Serial Number:**	0019
Landing Gear Type:	Skid	**Seats:**	6
Date/Type of Last Inspection:	11/24/1998, 100 Hour	**Certified Max Gross Wt.:**	5998 lbs
Time Since Last Inspection:	21 Hours	**Engines:**	2 Turbo Shaft
Airframe Total Time:	714 Hours	**Engine Manufacturer:**	P&W
ELT:	Installed, not activated	**Engine Model/Series:**	206 B
Registered Owner:	DEBIS FINANCIAL SERVICES INC	**Rated Power:**	732 hp
Operator:	AERIAL FILMS INC.	**Operating Certificate(s) Held:**	None

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual Conditions	**Condition of Light:**	Night/Bright
Observation Facility, Elevation:	EWR, 18 ft msl	**Distance from Accident Site:**	5 Nautical Miles
Observation Time:	1751 EST	**Direction from Accident Site:**	204°
Lowest Cloud Condition:	Unknown / 0 ft agl	**Visibility**	10 Miles
Lowest Ceiling:	Broken / 25000 ft agl	**Visibility (RVR):**	0 ft
Wind Speed/Gusts:	7 knots /	**Turbulence Type Forecast/Actual:**	/
Wind Direction:	240°	**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:	29 inches Hg	**Temperature/Dew Point:**	63°C / 45°C
Precipitation and Obscuration:			
Departure Point:	NORTH BERGEN, NJ (07NJ)	**Type of Flight Plan Filed:**	None
Destination:	CALDWELL, NJ (CDW)	**Type of Clearance:**	
Departure Time:	1645 EST	**Type of Airspace:**	Class B

Wreckage and Impact Information

Crew Injuries:	1 Minor	**Aircraft Damage:**	Destroyed
Passenger Injuries:	1 Minor	**Aircraft Fire:**	In-Flight
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	2 Minor	**Latitude, Longitude:**	

Administrative Information

Investigator In Charge (IIC):	ROBERT L HANCOCK	**Report Date:**	04/11/2001
Additional Participating Persons:	JEFF SHAPIRO; TETERBORO, NJ ROBERT REULAND; GRAND PRAIRIE, TX ROBERT JACKSON; LONGUIEL, QB, CD CINDY CAUSEY; EAST WINDSOR, CT		
Publish Date:			
Investigation Docket:	NTSB accident and incident dockets serve as permanent archival information for the NTSB's investigations. Dockets released prior to June 1, 2009 are publicly available from the NTSB's Record Management Division at pubinq@ntsb.gov, or at 800-877-6799. Dockets released after this date are available at http://dms.ntsb.gov/pubdms/.		